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DOCUMENT-IDENTIFIER: US 20030225495 A1
TITLE: Complete vehicle control

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Summary of Invention Paragraph:
[0005] One aspect of the present invention is to provide a method of controlling a vehicle. The method includes the step of inputting an intended driving demand to a vehicle motion control subsystem, with the intended driving demand requesting a vehicle behavior modification. The method also includes the steps of proving a plurality coordinator subsystems, providing at least one actuator control subsystem for each coordinator subsystem, outputting actuator capabilities of the at least one actuator control subsystem to an associated one of the plurality of coordinator subsystems, and outputting coordinator capabilities of each coordinator subsystem to the vehicle motion control subsystem. The method further includes the step of calculating at least one coordinator demand signal with the vehicle motion control subsystem, with the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand. The method also includes the step of outputting the at least one coordinator demand signal to at least one of the coordinator subsystems. The method further includes the step of calculating the at least one coordinator demand signal with each of the at least one of the coordinator subsystems, with the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal. The method also includes the step of outputting the at least one actuator demand signal to the at least one actuator control subsystem. A combination of each at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

Summary of Invention Paragraph:
[0006] Another aspect of the present invention is to provide a vehicle control system comprising a vehicle motion control subsystem, a plurality of coordinator subsystems and at least one actuator control subsystem. The vehicle motion control subsystem has a control input and a control output, with the control input communicating an intended driving demand to the vehicle motion control subsystem. The intended driving demand requests a vehicle behavior modification. Each coordinator subsystem includes a coordinator input and a coordinator output, with each coordinator subsystem communicating coordinator capabilities of the coordinator subsystem to the system input of the vehicle motion control subsystem. At least one actuator control subsystem is provided for each coordinator subsystem. Each actuator control subsystem has an actuator output communicating actuator capabilities of the actuator control subsystem to the coordinator input of an associated one of the plurality of coordinator subsystems. The vehicle motion control subsystem calculates at least one coordinator demand signal, with the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand. The vehicle motion control subsystem also outputs the at least one coordinator demand signal to the coordinator input of

at least one of the coordinator subsystems. Furthermore, each coordinator subsystem calculates at least one actuator demand signal, with the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal. Additionally, each coordinator subsystem outputs the at least one actuator demand signal to at least one actuator control subsystem. A combination of each at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

Detail Description Paragraph:
[0017] Referring to FIG. 1A, reference number 10 generally designates a first portion of a vehicle control system embodying the present invention. In the illustrated example, the first portion 10 of the vehicle control system includes a vehicle motion control subsystem 12 that has an input receiving an intended driving demand 14 and a plurality of coordinator subsystems 16 for coordinating actuators of the vehicle. The vehicle motion control subsystem 12 communicates with the coordinator subsystems 16 to determine the capabilities of the coordinator subsystems 16 for carrying out the intended driving demand 14. The vehicle motion control subsystem 12 will distribute demand signals among one or more of the coordinator subsystems 16 to allow the vehicle to implement the intended driving demand 14.

Detail Description Paragraph:
[0022] In the illustrated example, the coordinator subsystems 16 communicate with the vehicle motion control subsystem 12 for receiving inputs for carrying out the intended driving demand 14. The coordinator subsystems 16 preferably include the steering coordinator subsystem 18, the drive train and brakes coordinator subsystem 20, and the suspension coordinator subsystem 22. Each of the coordinator subsystems 16 include an input that receives a signal from the vehicle motion control subsystem 12 commanding the coordinator subsystem 16 to implement a particular vehicle behavior modification. Therefore, the steering coordinator subsystem 18 receives a steering behavior modification demand signal conveying a steering behavior modification demand from the vehicle motion control subsystem 12. The steering behavior modification demand instructs the steering coordinator subsystem 18 to make a steering behavior modification (e.g., steer the vehicle in a certain lateral direction). Likewise, the drive train and brakes coordinator subsystem 20 receives a drive train and brakes behavior modification demand signal conveying a drive train and brakes behavior modification demand from the vehicle motion control subsystem 12. The drive train and brakes behavior modification demand instructs the drive train and brakes coordinator subsystem 20 to make a drive train and brakes behavior modification (e.g., move the vehicle in a certain longitudinal direction). Moreover, the suspension coordinator subsystem 22 receives a suspension behavior modification demand signal conveying a suspension behavior modification demand from the vehicle motion control subsystem 12. The suspension behavior modification demand instructs the suspension coordinator subsystem 22 to make a suspension behavior modification (e.g., manipulate the vehicle in a certain vertical (heave) direction). Each behavior modification demand of the coordinator subsystems 16 can also affect the motion of the vehicle in other directions. For example, the steering coordinator subsystem 18 can affect the yaw motion of the vehicle by turning the front wheels of the vehicle and can affect the roll motion of the vehicle by turning (thereby causing the side of the vehicle with the smaller turning radius to roll upward). As additional examples, the drive train and brakes coordinator subsystem 20 can affect the yaw motion by braking only one side of the vehicle and the suspension coordinator subsystem 22 can affect the longitudinal motion of the vehicle by altering the suspension of the vehicle to provide for improved traction. Furthermore, as discussed in more detail below, each coordinator subsystem 16 also provides an output to the vehicle motion control subsystem 12 for communicating capabilities of the coordinator subsystems 16. The capabilities of the coordinator subsystems 16 are the combination of the actuator control subsystems 26 communicating with an associated coordinator subsystem 16. Although

three coordinator subsystems 16 are shown and described herein, it is contemplated that any number of coordinator subsystems 16 can be used in the vehicle control system.

Detail Description Paragraph:
[0036] The illustrated vehicle control system of the present invention enhances the performance of the vehicle by distributing commands from the vehicle motion control subsystem 12 to the coordinator subsystems 16 based upon physical capabilities of the actuator control subsystems 26. Referring to FIGS. 5A and 5B, a method 50 of controlling a vehicle with the vehicle control system is shown. Beginning at step 52 of the method 50 of controlling the vehicle, the driver inputs from the driver 11 of the vehicle are inputted into the driver subsystem 15. The driver inputs are processed as discussed above and then sent to the active assist subsystem 17 at step 54.

Detail Description Paragraph:
[0038] The next three steps in the method of controlling a vehicle occur continuously, even if the intended driving demand 14 is not being input into the vehicle motion control subsystem 12. First, the vehicle state measurements are inputted into the vehicle motion control subsystem 12 from the vehicle state estimator 28 and data therefrom is transferred to each control tier in the vehicle control system at step 62. Second, the coordinator subsystems 16 will determine their capabilities at step 64. As discussed in more detail below, the capabilities of each coordinator subsystem 16 are a combination of all of the capabilities of the actuator control subsystems 26 functionally located under each coordinator subsystem 16 as determined by the data of the vehicle state measurements and measurements from actuator state estimators communicating with each actuator control subsystem 26. For example, a first one of the coordinator subsystems 16 can be the drive train and brakes coordinator subsystem 20 determining that it is capable of providing up to 3.0 Newton meters of braking wheel torque as measured by a combination of the braking wheel torque capabilities of the actuator control subsystems 26 communicating with the drive train and brakes coordinator subsystem 20. Although the drive train and brakes coordinator subsystem 20 is used in the above example, the coordinator subsystems 16 in step 64 could be any of the coordinator subsystems 16. Third, the coordinator subsystems 16 will output their capabilities to the vehicle motion control subsystem 12 at step 66.

Detail Description Paragraph:
[0039] After the intended driving demand 14 has been input into the vehicle motion control subsystem 12 at step 58 or 60, the vehicle motion control subsystem 12 will calculate at least one of a first demand signal, a second demand signal and a third demand signal at step 68. The calculation at step 68 is dependent on the capabilities of the first, second and third coordinator subsystems 16. The demand signals to the coordinator subsystems 16 will preferably not demand more from the coordinator subsystems 16 than a particular coordinator subsystem 16 is capable of providing as determined by the capability of the particular coordinator subsystem 16. For example, if the steering coordinator subsystem 18 is only capable of providing 3.0 Newton meters of yaw torque by altering the angles of the wheels and the intended driving demand requires 3.5 Newton meters of yaw torque, the vehicle motion control subsystem 12 will calculate a first demand signal for the steering coordinator subsystem 18 for 3.0 Newton meters (or less) of yaw torque and will send out a second demand signal to the drive train and brakes coordinator 20 requesting 0.5 Newton meters of yaw torque by instructing the drive train and brakes coordinator 20 to brake (braking wheel torque) one side of the vehicle (if possible). Therefore, the vehicle motion control subsystem 12 can output the first demand signal, the second demand signal and/or the third demand signal to the steering coordinator subsystem 18, the drive train and brakes coordinator subsystem 20 and the suspension coordinator subsystem 22, respectively, to accomplish the 3.5 Newton meters of yaw torque. Preferably, the vehicle motion control subsystem 12 will send out demand signals that do not require the coordinator subsystems 16 to

perform up to their full capabilities. Therefore, the demand signals sent to each coordinator subsystem 16 will depend on the capabilities of the coordinator subsystem 16 and/or the capabilities of the other coordinator subsystems 16. The demand signal sent to a first coordinator subsystem 16, when more than one demand signal is calculated, will depend on the demand signal sent to a second coordinator subsystem 16, which depends on the capabilities of the second coordinator subsystem 16.

Detail Description Paragraph:
[0041] The illustrated suspension coordinator subsystem 22 of the present invention also enhances the performance of the suspension of the vehicle by distributing commands from the suspension coordinator subsystem 22 to the actuator control subsystems 26 functionally located below the suspension coordinator subsystem 22 based upon physical capabilities of the actuator control subsystems 26. Referring to FIG. 6, a method 200 of controlling a suspension of a vehicle with the suspension coordinator subsystem 22 subsystem is shown. Beginning at step 202 of the method 200 of controlling the suspension of the vehicle, the suspension behavior modification demand signal is inputted into the suspension coordinator subsystem 22. The suspension behavior modification demand signal is a signal sent to the suspension coordinator subsystem 22 directing the suspension coordinator subsystem 22 to perform a particular behavior modification of the suspension of the vehicle (i.e., the suspension behavior modification).

Detail Description Paragraph:
[0042] The actuator control subsystems 26 receive the vehicle state measurements from the vehicle state estimator 28 (via the motion control subsystem 12 and the suspension coordinator subsystem 22) that provide the state of the vehicle and actuator state measurements from an actuator state estimator that provide the state of the actuators at step 204. As seen in FIG. 1, the vehicle state measurements are preferably transferred to the actuator control subsystems 26 through the vehicle motion control subsystem 12 and the suspension coordinator subsystem 22, although it is contemplated that the vehicle state measurements could be directly inputted into the actuator control subsystems 26. The actuator state measurements are preferably inputted directly into the actuator control subsystems 26. After the vehicle state measurements and actuator state measurements are inputted into the actuator control subsystems 26, the actuator control subsystems 26 will determine their capabilities to perform functions with the vehicle in the state of the vehicle state measurements and actuator state measurements at step 206. The vehicle state measurements are used to determine the capabilities of the actuator control subsystems 26 because the vehicle state measurements will communicate the speed of the vehicle, the movement of the vehicle in six directions, etc. to the actuator control subsystems 26, all of which are used along with the actuator state measurements (which provide the current state of the actuators of and controlled by the actuator control subsystems 26) to determine the capabilities of the actuator control subsystems 26. For example, a first actuator control subsystem 26 can be the leveling control subsystem 46 determining that it is capable of providing up to 3.0 Newtons of vertical force as determined by the load of the vehicle (a vehicle state measurement) and possible air input into an air-suspension level-control system (an actuator state measurement). Although the leveling actuator control subsystem 46 is used in the above example, the actuator control subsystem 26 could be any of the actuator control subsystems 26 under the suspension coordinator subsystem 22. Furthermore, although the step 202 of inputting the suspension behavior modification demand into the suspension coordinator subsystem 22 is shown as occurring before the step 204 of receiving the vehicle state measurements and the actuator state measurements by the first actuator control subsystem 26 and the step 206 of determining the actuator capabilities of the actuator control subsystems 26, steps 204 and 206 can occur simultaneously to or before the step 202 of inputting the suspension behavior modification demand into the suspension coordinator subsystem 22. Preferably, both steps 204 and 206 will occur continuously in the vehicle control system.

Detail Description Paragraph:
[0043] After the actuator control subsystems 26 have determined their capabilities, each actuator control subsystem 26 will output a capability signal to the suspension coordinator subsystem 22 communicating the capabilities of each actuator control subsystem 26 at step 208. At this point, the suspension coordinator subsystem 22 will then calculate at least one partial suspension behavior modification demand signal at step 210 (along with combining the capabilities of the actuator control system 26 to form the coordinator capability of the suspension coordinator subsystem 22 for reporting to the vehicle motion control subsystem 12 as discussed above). A first partial suspension behavior modification demand signal will tell a first actuator control subsystem 26 to perform within its first capabilities. Likewise, a second partial suspension behavior modification demand signal will tell a second actuator control subsystem 26 to perform within its second capabilities. Moreover, a third partial suspension behavior modification demand signal will tell a third actuator control subsystem 26 to perform within its third capabilities. Consequently, the first partial suspension behavior modification demand signal, the second partial suspension behavior modification demand signal and/or the third partial suspension behavior modification demand signal will provide directions for a first actuator control subsystem 26, the second actuator control subsystem 26 and/or the third actuator control subsystem 26, respectively, to perform the suspension behavior modification of the suspension behavior modification demand signal. Furthermore, the first partial suspension behavior modification demand signal, the second partial suspension behavior modification demand signal and the third partial suspension behavior modification demand signal are therefore calculated according to the first capabilities of the first actuator control subsystem 26, the second capabilities of the second actuator control subsystem 26 and/or the third capabilities of the third actuator control subsystem 26. For example, if the suspension behavior modification demand signal requires more from a single actuator control subsystem than it is capable of providing (as determined by its capabilities), more than one partial suspension behavior modification demand signal will be calculated, with a first partial suspension behavior modification demand signal being determined according to the capabilities of a first actuator control system (i.e., requesting the first actuator control system to perform within its capabilities) and a second partial suspension behavior modification demand signal that depends on the capabilities of the first actuator control subsystem (a suspension behavior modification demand of the suspension behavior modification demand signal remaining after the first partial suspension behavior modification demand signal is removed).

Detail Description Paragraph:
[0045] The illustrated drive train and brakes coordinator subsystem 22 of the present invention also enhances the performance of the drive train and brakes of the vehicle by distributing commands from the drive train and brakes coordinator subsystem 22 to the actuator control subsystems 26 based upon physical capabilities of the actuator control subsystems 26 functionally located below the drive train and brakes coordinator subsystem 22. Referring to FIG. 7, a method 300 of controlling a drive train and brakes of a vehicle with the drive train and brakes coordination 22 subsystem is shown. Beginning at step 302 of the method 300 of controlling the drive train and brakes of the vehicle, the drive train and brakes behavior modification demand signal is inputted into the drive train and brakes coordinator subsystem 22. The drive train and brakes behavior modification demand signal is a signal sent to the drive train and brakes coordinator subsystem 22 directing the drive train and brakes coordinator subsystem 22 to perform a particular behavior modification of the drive train and brakes of the vehicle (i.e., the drive train and brakes behavior modification).

Detail Description Paragraph:
[0046] The actuator control subsystems 26 receive the vehicle state measurements from the vehicle state estimator 28 (via the motion control subsystem 12 and the

drive train and brakes coordinator subsystem 22) that provide the state of the vehicle and actuator state measurements from an actuator state estimator that provide the state of the actuators at step 304. As seen in FIG. 1, the vehicle state measurements are preferably transferred to the actuator control subsystems 26 through the vehicle motion control subsystem 12 and the drive train and brakes coordinator subsystem 22, although it is contemplated that the vehicle state measurements could be directly inputted into the actuator control subsystems 26. The actuator state measurements are preferably inputted directly into the actuator control subsystems 26. After the vehicle state measurements and actuator state measurements are inputted into the actuator control subsystems 26, the actuator control subsystems 26 will determine their capabilities to perform functions with the vehicle in the state of the vehicle state measurements and actuator state measurements at step 306. The vehicle state measurements are used to determine the capabilities of the actuator control subsystems 26 because the vehicle state measurements will communicate the speed of the vehicle, the movement of the vehicle in six directions, etc. to the actuator control subsystems 26, all of which are used along with the actuator state measurements (which provide the current state of the actuators of and controlled by the actuator control subsystems 26) to determine the capabilities of the actuator control subsystems 26. For example, a first actuator control subsystem 26 can be the engine control subsystem 36 determining that it is capable of providing up to 3.0 Newton meters of wheel torque as determined by the speed of the vehicle (a vehicle state measurement) and possible fuel input into an engine (an actuator state measurement). Although the engine control subsystem 36 is used in the above example, the actuator control subsystem 26 could be any of the actuator control subsystems 26 under the drive train and brakes coordinator subsystem 22. Furthermore, although the step 302 of inputting the drive train and brakes behavior modification demand into the drive train and brakes coordinator subsystem 22 is shown as occurring before the step 304 of receiving the vehicle state measurements and the actuator state measurements by the first actuator control subsystem 26 and the step 306 of determining the actuator capabilities of the actuator control subsystems 26, steps 304 and 306 can occur simultaneously to or before the step of inputting the drive train and brakes behavior modification demand into the drive train and brakes coordinator subsystem 22. Preferably, both steps 304 and 306 will occur continuously in the vehicle control system.

Detail Description Paragraph:
[0047] After the actuator control subsystems 26 have determined their capabilities, each actuator control subsystem 26 will output a capability signal to the drive train and brakes coordinator subsystem 22 communicating the capabilities of each actuator control subsystem 26 at step 308. At this point, the drive train and brakes coordinator subsystem 22 will then calculate at least one partial drive train and brakes behavior modification demand signal at step 310 (along with combining the capabilities of the actuator control system 26 to form the coordinator capability of the drive train and brakes coordinator subsystem 22 for reporting to the vehicle motion control subsystem 12 as discussed above). A first partial drive train and brakes behavior modification demand signal will tell a first actuator control subsystem 26 to perform within its first capabilities. Likewise, a second partial drive train and brakes behavior modification demand signal will tell a second actuator control subsystem 26 to perform within its second capabilities. Moreover, a third partial drive train and brakes behavior modification demand signal will tell a third actuator control subsystem 26 to perform within its third capabilities. Consequently, the first partial drive train and brakes behavior modification demand signal, the second partial drive train and brakes behavior modification demand signal and/or the third partial drive train and brakes behavior modification demand signal will provide directions for a first actuator control subsystem 26, the second actuator control subsystem 26 and/or the third actuator control subsystem 26, respectively, to perform the drive train and brakes behavior modification of the drive train and brakes behavior modification demand signal. Furthermore, the first partial drive train and brakes behavior

modification demand signal, the second partial drive train and brakes behavior modification demand signal and the third partial drive train and brakes behavior modification demand signal are therefore calculated according to the first capabilities of the first actuator control subsystem 26, the second capabilities of the second actuator control subsystem 26 and the third capabilities of the third actuator control subsystem 26. For example, if the drive train and brakes behavior modification demand signal requires more from a single actuator control subsystem than it is capable of providing (as determined by its capabilities), more than one partial drive train and brakes behavior modification demand signal will be calculated, with a first partial drive train and brakes behavior modification demand signal being determined according to the capabilities of a first actuator control system (i.e., requesting the first actuator control system to perform within its capabilities) and a second partial drive train and brakes behavior modification demand signal that depends on the capabilities of the first actuator control subsystem (a drive train and brakes behavior modification demand of the drive train and brakes behavior modification demand signal remaining after the first partial drive train and brakes behavior modification demand is removed).

CLAIMS:

1. A method of controlling a vehicle comprising: inputting an intended driving demand to a vehicle motion control subsystem, the intended driving demand requesting a vehicle behavior modification; proving a plurality of coordinator subsystems; providing at least one actuator control subsystem for each coordinator subsystem; outputting actuator capabilities of the at least one actuator control subsystem to an associated one of the plurality of coordinator subsystems; outputting coordinator capabilities of each coordinator subsystem to the vehicle motion control subsystem; calculating at least one coordinator demand signal with the vehicle motion control subsystem, the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand; outputting the at least one coordinator demand signal to at least one of the coordinator subsystems; calculating at least one actuator demand signal with each of the at least one of the coordinator subsystems, the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal outputted to the at least one of the coordinator subsystems; and outputting the at least one actuator demand signal to the at least one actuator control subsystem; wherein a combination of each at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

7. The method of controlling a vehicle of claim 6, wherein: the coordinator capabilities for the associated one of the plurality of coordinator subsystems are determined according to the actuator capabilities of the at least one actuator control subsystem outputting the actuator capabilities to the associated one of the plurality of coordinator subsystems.

8. A vehicle control system comprising: a vehicle motion control subsystem having a control input and a control output, the control input communicating an intended driving demand to the vehicle motion control subsystem, the intended driving demand requesting a vehicle behavior modification; a plurality of coordinator subsystems, each coordinator subsystem including a coordinator input and a coordinator output, each coordinator subsystem communicating coordinator capabilities of the coordinator subsystem to the system input of the vehicle motion control subsystem; and at least one actuator control subsystem for each coordinator subsystem, each actuator control subsystem having an actuator output communicating actuator capabilities of the actuator control subsystem to the coordinator input of an associated one of the plurality of coordinator subsystems; wherein the vehicle motion control subsystem calculates at least one coordinator demand signal, the at least one coordinator demand signal being determined according to the coordinator

capabilities and the intended driving demand; wherein the vehicle motion control subsystem outputs the at least one coordinator demand signal to the coordinator input of at least one of the coordinator subsystems; wherein each coordinator subsystem calculates at least one actuator demand signal, the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal outputted to the at least one of the coordinator subsystems; wherein each coordinator subsystem outputs the at least one actuator demand signal to at least one actuator control subsystem; and wherein a combination of each at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

14. The vehicle control system of claim 13, wherein: the coordinator capabilities for the associated one of the plurality of coordinator subsystems are determined according to the actuator capabilities of the at least one actuator control subsystem outputting the actuator capabilities to the associated one of the plurality of coordinator subsystems.

16. The method of controller a vehicle of claim 15, wherein: the implementation subsystem includes a plurality coordinator subsystems and at least one actuator control subsystem for each coordinator subsystem; and further including the steps of: outputting actuator capabilities of the at least one actuator control subsystem to an associated one of the plurality of coordinator subsystems; outputting coordinator capabilities of each coordinator subsystem to the vehicle motion control subsystem; calculating at least one coordinator demand signal with the vehicle motion control subsystem, the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand; the step of outputting at least a portion of the intended driving demand includes outputting the at least one coordinator demand signal to at least one of the coordinator subsystems; calculating at least one actuator demand signal with each of the at least one of the the coordinator subsystems, the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal outputted to the at least one of the coordinator subsystem; and outputting the at least one actuator demand signal to the at least one actuator control subsystem; wherein the at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

18. The method of controlling a vehicle of claim 17, wherein: the coordinator capabilities for the associated one of the plurality of coordinator subsystems are determined according to the actuator capabilities of the at least one actuator control subsystem outputting the actuator capabilities to the associated one of the plurality of coordinator subsystems.

DOCUMENT-IDENTIFIER: US 20050125145 A1
TITLE: Electronic device and program for displaying map

Abstract Paragraph:
When a guiding route is included in a display target region at a photograph display mode, route data of the guiding route is also read. Within the read route data, information of a region for editing a photograph is stored. This information includes a road kind (color information), coordinates of the start/end points of the road, and a road width when editing is for a road. Next, photograph data is read, so that a color of the photograph data is edited based on the stored information of the route data. For instance, a color of the photograph data in a corresponding road region is changed to red that represents "national road."

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Summary of Invention Paragraph:
[0007] To achieve the above object, as a first aspect of the present invention, an electronic device for displaying a map is provided with the following. A map data storing unit stores map data. A photograph data storing unit stores photograph data photographing an earth surface. A display controlling unit causes a display unit to display photograph data of a display target region based on the photograph data read from the photograph data storing unit. A changing portion determining unit determines, within the photograph data of the display target region, a data portion whose display attribute is to be changed based on one of the map data stored in the map data storing unit and guiding route data obtained by using the map data stored in the map data storing unit. Here, the display controlling unit causes the display unit to display the photograph data after the display controlling unit changes, to a given attribute, the display attribute of the data portion determined by the changing portion determining unit.

Summary of Invention Paragraph:
[0008] In this first aspect of the present invention, the data portion whose display attribute is changed can include a road unit, or a site unit. This site unit means other than roads. Naturally, the data portion can be determined based on a road kind or a site kind. For instance, the road kind includes an expressway, a national road, or a prefectural road, while the site kind includes a railway line, a river, or an establishment. Further, the changed display attribute can include a display color.

Summary of Invention Paragraph:
[0009] Thus, only changing of a display attribute corresponding to a road obtained from map data suffices for highlighting on a display a display color corresponding to the road within a photograph. This does not superimpose a line on the photograph data likewise a conventional procedure, not hiding images on the photograph. This thereby enables a fine display without decreasing reality of the photograph. When the display attribute of the road is changed, the whole of the colors of the roads can be changed. However, for instance, only a guiding route (a route to a

destination) obtained from route retrieving can be changed in its display attribute. Further, a road or a color as a target of changing can be selected as needed by using road kinds. That is, a national road is changed to red; an expressway, to blue; others are not changed. This provides an easy viewable map display without becoming unsightly. In particular, when the guiding route is highlighted, only the guiding route can be effectively changed using a clearly recognizable color, while the others are not changed.

Summary of Invention Paragraph:
[0010] In a second aspect of the present invention, an electronic device for displaying a map is provided with the following. A photograph data storing unit stores photograph data whose display attribute is changed by being determined based on map data. The map data corresponds to a data portion whose display attribute is changed. The photograph data is formed by photographing an earth surface. A display control unit causes a display unit to display a display target region based on the photograph data read from the photograph data storing unit.

Summary of Invention Paragraph:
[0011] In the foregoing first aspect, photograph data and map data are separately stored, thereby determining in real time a portion for changing a display attribute within photograph data. This is very effective, e.g., when a guiding route is highlighted. Further, this is also effective when a user changes a target for changing its display attribute based on an occasional usage. Here, it is preferable that a user can select a display attribute within constituting elements or positions on map data. When instructions are inputted by the user, the photograph data can be thereby changed in display attributes according to the inputted instructions.

Summary of Invention Paragraph:
[0012] By contrast, in the second aspect, for instance, by identifying road kinds, a national road is changed to in red; an expressway, to in blue; further, others are not changed in color. Here, there is no need for performing in real time, so that photograph data whose display attribute is previously changed can be stored to be then displayed.

Detail Description Paragraph:
[0038] Next, the photograph data is read in the memory 29a from the external memory 28 (S150). Here, editing of the photograph data follows the information stored at Step S140 (S160). For instance, when a national road is displayed in red, a national road (road kind), color information (red), x, y coordinates (longitudes and latitudes) of respective ends of the national road, and a road width are stored. A color of the photograph data of the corresponding region is change to red according to the information. In detail, since the map of the same region is read in, position information (e.g., longitude and latitude) of a map constituent element of an editing target in the map data is obtained and then the corresponding dot portion within the photograph data is changed in color. Here, an editing target can be only a color, but also, a thickness or kind of a line can be changed, instead. To maintain a reality image, editing of the color is preferable.

Detail Description Paragraph:
[0040] As explained above, only one photograph data is present to one area, while the map data is classified into 5 levels. Therefore, data as roads is different between the wide area map and the detail map. By contrast, since the photograph data is formed by photographing actual earth surfaces, any detail roads are photographed even though the resolution of the images of the detail roads is not maintained at a given level. When the detail map is displayed by enlarging the photograph data, the detail roads are possibly unclearly recognized. By contrast, the detail map data includes information designating a position of the road. Therefore, when the corresponding dot portion within the photograph data is changed in color or the like based on the designating information, the presence of the road

can be clearly recognized.

Detail Description Paragraph:
[0042] (1) According to the map display process 1 explained with reference to FIG. 3, when a display color of a road portion within a photograph is highlighted, only a display attribute of a portion corresponding to the road portion obtained from map data is changed. This does not superimpose a line on the photograph data likewise a conventional procedure, while this does not hide images on the photograph. This thereby enables a fine display without decreasing reality of the photograph. When the display attribute of the road is changed, the whole of the colors of the relevant roads can be changed. However, for instance, only a guiding route (a route to a destination) obtained from route retrieving can be changed in its display attribute. Further, a road or a color as a target of changing can be selected as needed by using road kinds. That is, a national road is changed to red; an expressway, to blue; others are not changed. This provides an easy viewable map display without becoming unsightly. In particular, when the guiding route is highlighted, it is very effective for only the guiding route to be changed using a clearly recognizable color while the other are not changed.

Detail Description Paragraph:
[0043] Furthermore, when the display attribute is a display color, in addition to changing the display color itself, color tones (or hues) in the corresponding dots can be also adjusted so that the map data can be superimposed on the photo data with a natural display enabled, in comparison with changing of the display color alone. Namely, the photo data primarily has hues, while the map data has uniform display colors. Therefore, simple superimposition of the map data (i.e., display color) on the photo data often produces mismatching with the background of the photo data. Consequently, the changed display color is additionally adjusted based on the original color tones of the photo data. This achieves a natural display color in the superimposition of the map data on the photo data.

Detail Description Paragraph:
[0046] (2) In the above map display process 1, editing processing such as changing a color of the road or the like in displaying the photograph data is executed in a real time basis. Namely, in the map display process 1, photograph data and map data are separately stored, thereby determining in real time a portion for changing a display attribute within photograph data. This is very effective, e.g., when a guiding route is highlighted. Further, this is also effective when a user changes a target for changing its display attribute based on an occasional usage. Here, it is preferable that a user can select a display attribute within constituting elements or positions on map data. When instructions are inputted by the user, the photograph data can be thereby changed in display attributes according to the inputted instructions.

Detail Description Paragraph:
[0047] By contrast, in the modified map display process, for instance, by identifying road kinds, a national road is changed to in red; an expressway, to in blue; further, others are not changed in color. Here, there is no need for performing in a real time basis, so that photograph data whose display attribute is previously changed can be stored to be thereafter displayed. Namely, when the photograph data is stored in the storage such as a DVD-ROM, a CD-ROM, or an HDD, the editing processing similar to that in the map display process 1 is executed and the edited photograph data can be stored in the storage. Further, the adjusted color tones described in the above can be also stored as part of edited photograph data. However, this modification cannot be applied to a route to a destination dynamically changing since the corresponding photo data of the route to the destination cannot be previously edited.

Detail Description Paragraph:
[0048] (3) In the current navigation device, a display color is changed depending

on turning on or off of an in-vehicle lighting device (e.g., head light). Therefore, when the photograph data is used in the above embodiment, a color editing procedure can be prepared for two types of the turning-on and turning-off.

Detail Description Paragraph:
[0051] It will be obvious to those skilled in the art that various changes may be made in the above-described embodiments of the present invention. However, the scope of the present invention should be determined by the following claims.

CLAIMS:

1. An electronic device for displaying a map, the electronic device comprising: a map data storing unit that stores map data; a photograph data storing unit that stores photograph data photographing an earth surface; a display controlling unit that causes a display unit to display photograph data of a display target region based on the photograph data read from the photograph data storing unit; and a changing portion determining unit that determines, within the photograph data of the display target region, a data portion whose display attribute is to be changed based on one of the map data stored in the map data storing unit and guiding route data obtained by using the map data stored in the map data storing unit, wherein the display controlling unit causes the display unit to display the photograph data after the display controlling unit changes, to a given attribute, the display attribute of the data portion determined by the changing portion determining unit.

3. The electronic device of claim 2, wherein the display color is changed while resultant color tones in dots corresponding to the data portion determined by the changing portion determining unit are adjusted based on the photo data.

5. An electronic device for displaying a map, the electronic device comprising: a photograph data storing unit that stores photograph data whose display attribute is changed by being determined based on map data, wherein the map data corresponds to a data portion whose display attribute is changed, wherein the photograph data is formed by photographing an earth surface; and a display control unit that causes a display unit to display a display target region based on the photograph data read from the photograph data storing unit.

7. The electronic device of claim 6, wherein the display color is changed while resultant color tones in dots corresponding to the data portion determined by the changing portion determining unit are adjusted based on the photo data.

9. A method for displaying a map using map data and photograph data photographing an earth surface, the method comprising steps of: determining, within photograph data of a display target region, a data portion whose display attribute is to be changed based on one of the map data and guiding route data obtained by using the map data; and causing a display unit to display the photograph data after the display attribute of the determined data portion is changed to a given attribute.

10. A computer program product in a computer-readable medium for use in displaying a map using map data and photograph data photographing an earth surface, the computer program product comprising instructions of: determining, within photograph data of a display target region, a data portion whose display attribute is to be changed based on one of the map data and guiding route data obtained by using the map data; and causing a display unit to display the photograph data after the display attribute of the determined data portion is changed to a given attribute.

L14: Entry 2 of 2 File: PGPB Feb 12, 2004

DOCUMENT-IDENTIFIER: US 20040029558 A1
TITLE: Method and system for determining a location of a wireless transmitting device and guiding the search for the same

Summary of Invention Paragraph:
[0007] Wireless devices include cellular, PCS (Personal Communication Systems), cordless and satellite phones, wireless PDAs (Personal Digital Assistants) and laptop computers, two-way pagers, radio tags, etc. Collectively these are referred to herein as "wireless devices".

Summary of Invention Paragraph:
[0010] A notable emergency response service is the enhanced 911 (E911) service mandated by the FCC (Federal Communications Commission) for all cellular licensees, broadband Personal Communications Service (PCS) licensees, and certain Specialized Mobile Radio (SMR) licensees in the United States. E911 service is to provide the operators at the PSAP (Public Safety Answering Point) with information such as calling number, location of serving base station, and caller's Automatic Location Identification (ALI) in longitude and latitude. This automatic information enables the PSAP operators to dispatch emergency response teams for wireless 911 callers in the similar fashion as for the wire line 911 callers. The location accuracy and reliability required by FCC have been revised several times since their first release, compromising what is needed and what is possible. At the time of this invention, the requirements are

Summary of Invention Paragraph:
[0021] Depending on the application, wireless location systems face various technological challenges. Achieving high location accuracy anywhere, anytime, under diversified terrain conditions, and at a low cost is a challenge common to many location applications. Particularly for conventional E911 technologies, the prior art solutions are divided into two major categories: network based and handset based. In network based prior art solutions, location accuracy is sensitive to multipath propagation, number of available detection stations, and geographical geometry of the target in relation to the available detection stations. In handset based prior art solutions using GPS, location accuracy is susceptible to blockage in dense urban areas and inside buildings. The handset based prior art solutions also have problems to provide E911 service to legacy devices already in use. To achieve a required accuracy throughout coverage areas and terrains, the cost is often found far beyond the acceptable limit for operators and many end users. In addition, the prior art E911 solutions do not address the need to guide the search for the target on site.

Summary of Invention Paragraph:
[0023] In one aspect of this invention, the method utilizes a system that is composed of one or a plurality of detection stations (DS), at least one of the DSs is carried on board of a moving platform (herein referred to as a Movable Detection Station, or MDS, for short), for examples, on board of a police car, an ambulance, a fire truck, a helicopter, a balloon, an airship, a boat, or the like, or carried in hand or on shoulder by the operator of the MDS. Either operating alone or

operating in conjunction with other DS and MDS, a MDS measures the location of the TD while moving en route to or around the TD. The method thereby involves making use of the advantages that are made available by the mobility of the MDS, by the movement of the MDS, and by the close distances of the MDS with respect to the TD.

Brief Description of Drawings Paragraph:
[0032] FIG. 5 is an exemplary illustration of preferred display on screen for absolute and relative locations of TD, GRD(s) and MDS(s) in two dimensions, overlaid with local area map and remote sensing photo that are pre-stored on system;

Detail Description Paragraph:
[0038] In the description hereafter, a cellular phone is used as an example of the Target Device (TD) for convenience of description. It is understood that the method and system described herein do not limit its TD to a cellular phone. Depending on the functionality provided by the TD, the TD may be a cellular phone, a PCS (Personal Communication Systems) phone, a satellite phone, a cordless phone, a two-way pager, a wireless PDA (Personal Digital Assistant), a wireless laptop computer, a data messaging device, a cellular telephone with data messaging capabilities, a wireless Internet appliance, a data communication device (with or without telephony capabilities), or a radio tag, and so on.

Detail Description Paragraph:
[0040] FIG. 1 illustrates the location determination system and the method associated with thereof, in the on-vehicle operation mode, using a cellular phone as an example of TD. Referring to FIG. 1, the TD 10 is a wireless transmitting device whose location is to be determined and searched. The particular TD shown in the figure is a cellular phone that is communicating with a Base Station (BS) 20A through radio link 40A, and in some circumstances (e.g., for a CDMA TD in a soft handoff) also communicating with additional BSs simultaneously, such as with BS 20B via radio link 40B shown also in the figure. The TD 10 is transmitting wireless signals, for example, in verbal communication with an operator at a Public Safety Answering Point (PSAP, not shown in the figure) after dialing the emergency number "911" adopted in the North America, or staying on the line quietly after dialing "911", or being called back by an emergency response officer after hanging up his/her "911" call, or being initiated a wireless transmitting session in a Service Option that is specifically designed for location service, e.g., transmitting a pilot signal. Upon receipt of the "911" call, the PSAP operator would obtain the caller's rough location by means of verbal conversation, and/or by prior art "Phase I" E911 information that is automatically reported to PSAP by the wireless network in terms of serving BS 20A location, and the round trip delay that may also be available, and/or by prior art "Phase II" E911 information that is reported to PSAP in terms of longitude and latitude of TD 10, whose corresponding location is denoted in the figure as 60, that is subject to errors statistically. Emergency response vehicles equipped with Movable Detection Station (MDS) 30A, 30B such as police cars, ambulances, and/or fire trucks are dispatched by PSAP to said rough location. Those skilled in the art understand that the parameters or properties of the transmitted signal by the TD 10, such as the transmitting frequency of the TD, the transmitting slot position of the TD when the TD is operating in TDMA (Time Division Multiple Access) mode, the spreading code information of the TD when the TD is operating in CDMA (Code Division Multiple Access) mode or DSSS (Direct Sequence Spread Spectrum) mode, the frequency hoping information when the TD is operating in frequency hopping mode, phone number, and/or electrical serial number (ESN), can be made available to the MDS 30A, 30B from a database installed within or connected to the PSAP, from the wireless network which is connected to the PSAP, and/or from the air interface of the wireless communication system. Using said parameters or properties, the receivers of MDS 30A, 30B would attempt to acquire and receive the transmitted signal 50A, 50B from the TD 10, while driving en route to the target location. As shown in the figure, along the route the MDS 30A would take a plurality of measurements of the incoming signal 50A', 50A while moving from

position 30A' to position 30A, and when taking each of the measurements, the position and orientation of MDS 30A can also be determined using such means as GPS receiver installed on MDS 30A. The plurality of measurements on parameters of the incoming signal 50A', 50A that are performed at different time instants and different positions 30A, 30A', etc., along the route, together with the corresponding positions and orientations of MDS 30A that are determined can be transformed into appropriate location estimation methods that are originally proposed for multiple fixed detection stations that take measurements at same time instants. Along the route, the MDS 30A would continuously take new measurements and continuously refine the estimation of the TD 10 location. Those skilled in the art understand that, in the prior art network based solutions the number of available DSs (usually co-located at the BSs) that "hear" the signal from TD 10 are often found too few, especially in suburban and rural areas; the location geometry of available DSs in prior art that "hear" the signal from TD 10 with respect to the location of TD is often found disadvantageous to the accuracy of the location measurement; the blockage to the line of sight (LOS) propagation path and the multipth propagation effects in urban and suburban areas often cause the DSs at the fixed locations in the prior art network based solutions to produce unacceptable location measurement errors. By using MDS the number of measurements that can be obtained along the route of a MDS movement can be hundreds if not thousands; among them, measurements taken at disadvantageous positions can be excluded or weighted low. The disadvantageous measurements include those having low signal to interference ratios or signal to noise ratios, those of which the LOS or earliest arrival paths are weak or lost; those do not exhibit advantageous geometry with tentatively measured TD location. Said exclusion or weighting process is progressive, i.e., a relatively good measurement will be kept while no better ones are available so far, but once sufficient better measurements become available, those previously preserved relatively "good" ones become not-good-enough and are excluded or weighted lower, and such updating process continues. The detection of the signal to interference ratio or signal to noise ratio can be accomplished by a signal to interference ratio estimator or a signal to noise ratio estimator that is familiar to the skilled in the art; the detection of late arrival multipath propagation paths in an individual measurement for purpose of exclusion in the location calculation can be implemented by a channel impulse response estimator that is familiar to the skilled in the art; disadvantageous geometry with tentatively measured TD location can be measured by geometrical dilution of position (GDOP), which is also well known to the skilled in the art and does not need further explanation. A method that determines whether or not an individually detected earliest arrival propagation path is truly LOS or truly earliest arrival propagation path will be further described subsequently with reference to FIG. 3. The mobility of the MDS can actually correct the measured errors that are caused by blockage of LOS and the multipath propagation through its ray tracing process. This is further explained next by referring to FIG. 2.

Detail Description Paragraph:
[0042] FIG. 3 is an illustration of a method of determining whether or not an individually detected earliest arrival propagation path is truly LOS or truly earliest arrival propagation path, in a fictitious multipath scattering environment that applies to a MDS. Referring now to FIG. 3. A MDS 30 moves along the road and takes measurement on the signals transmitted by TD 10 at positions 30A, 30A' and 30A". Buildings A, B, C, and D in the surrounding area form blockage and/or reflection land structures to the signal propagations from TD 10 to MDS 30. At position 30A, the MDS 30 detects a propagation path 50A.sub.1 reflected from building C, but the LOS propagation path 50A.sub.2 is too weak to be detected due to blockage by building A. Therefore, although arriving later than 50A.sub.2, 50A.sub.1 is the detected earliest arrival propagation path at position 30A. When the MDS 30 arrives at position 30A', the LOS propagation path 50A'.sub.3 is still too weak to be detected due to blockage by building A, however MDS 30 can detect propagation path 50A', and 50A'.sub.2 reflected from building C and B, respectively. Between 50A'.sub.1 and 50A'.sub.2, the MDS 30 can determine that

50A'.sub.2 arrives earlier than 50A'.sub.1 through its means to distinguish multipaths. Therefore, 50A'.sub.1 is determined NOT to be earliest arrival propagation path, while 50A'.sub.2 is the individually detected earliest arrival propagation path at position 30A'. Whether or not the 50A'.sub.2 is truly earliest arrival propagation path is still undetermined solely based on measurement taken at position 30A'. Now, based on the measurements taken at two positions, 30A and 30A', we try to determine jointly whether the individually detected earliest arrival propagation paths, 50A'.sub.1 and 50A'.sub.2 are truly LOS propagation path or truly earliest arrival path. The method is to measure the difference of the propagation delays of the individually detected earliest arrival propagation paths from TD 10 to MDS 30 at the two positions, 30A and 30A', and also determine the distance between the two positions 30A and 30A'; if the delay difference is larger than the distance divided by the speed of light, then, between the two paths, the longer delay path is determined NOT truly LOS propagation path, or NOT truly earliest arrival propagation path; if the delay difference is not larger than the distance divided by the speed of light, then both paths are still UNCERTAIN whether they are truly LOS propagation paths or truly earliest arrival propagation paths. In this example, if the delay from TD 10 to building C and then to 30A is longer than that from TD 10 to building B and then to 30A' by an amount of distance between 30A and 30A' divided by the speed of light, then the individually detected earliest arrival propagation path 50A'.sub.1 is NOT truly LOS propagation path or NOT truly earliest arrival propagation path; if the said former delay is shorter than said latter delay by the same said amount, then the individually detected earliest arrival propagation path 50A'.sub.2 is NOT truly LOS propagation path or NOT truly earliest arrival propagation path; otherwise, both individually detected earliest arrival propagation paths 50A.sub.1 and 50A'.sub.2 are still UNCERTAIN whether they are truly LOS propagation path or truly earliest arrival propagation path, solely based on measurements taken at positions 30A and 30A'. When the MDS 30 arrives at position 30A", we see in FIG. 3 that MDS 30 observes the LOS propagation path 50A", however MDS 30 itself does not know about this fact and it still needs to use said individual and said joint method to determine it. In the joint determination method, MDS 30 will measure the delay difference of paths 50A" and 50A'.sub.2, and determine the distance between 30A" and 30A', use said rules to find out whether any of the paths 50A" and 50A'.sub.2 can be determined as NOT truly LOS propagation path or NOT truly earliest arrival propagation path. If the paths 50A" and 50A.sub.1 still remain UNCERTAIN whether they are truly LOS propagation path or truly earliest arrival propagation path, the method can also be further applied to the pair of measurements obtained at positions 30A" and 30A, using the corresponding delay difference and distance between positions 30A" and 30A. While MDS 30 continues to drive further, the method can be further used between any pair of measurements taken along the route where the associated individually detected earliest arrival propagation path remains UNCERTAIN whether it is truly LOS propagation path or truly earliest arrival path.

Detail Description Paragraph:
[0047] Now referring to FIG. 5. FIG. 5 is an exemplary illustration of preferred display on screen for absolute and relative locations of TD, GRD(s) and MDS(s) in two dimensions. Preferably the display is in color (not being able to shown on FIG. 5 due to document format limitation), the symbols that mark the measured locations of TD 10, GRD 100A,100B and MDS 30A,30B are overlaid with local area map, and preferably further overlaid with pre-stored remote sensing photo that shows the land structures.

Detail Description Paragraph:
[0048] FIG. 6 illustrates an alternative embodiment of the location determination system in which the MDS 30A,30B are equipped with an on-MDS BS transmitter, and the method associated with thereof, in the on-vehicle and the off-vehicle operation modes, using a cellular phone as an example of target device. Now referring to FIG. 6, in the same way as in the description of FIG. 1, after TD 10 calls 911, the PSAP (not shown in the figure) dispatches the emergency response vehicles that are

equipped with MDS 30A,30B to the rough location according to the information obtained by the said PSAP; the TD 10 is transmitting signals to communicate with its serving BS 20A via radio link 40A and in some cases simultaneously with additional BSs, such as BS 20B via the radio link 40B; when the MDS 30A,30B are close enough to the location of TD 10, the MDS 30A,30B can detect the signal being transmitted by TD 10 via radio link 50 and the up link direction of radio link 200 (the direction from TD 10 to MDS 30A) and can start to measure and refine the location of TD 10. At a point when the radio link between TD 10 and one of the dispatched emergency response vehicles, say the link 200 between TD 10 and MDS 30A, becomes of better quality than that of link 40A (and if available, 40B), the corresponding MDS 30A would enable its on-MDS BS transmitter within MDS 30A, and informs the serving BS 20A to send handoff/handover command to TD 10. The said handoff/handover command asks TD 10 to handoff/handover to MDS 30A. Receiving and executing said handoff/handover command, the TD 10 then establishes two-way communication with MDS 30A via radio link 200, and disconnects the radio link(s) 40A (and 40B if available). Because of the close-in distance between TD 10 and MDS 30A and thus the better quality of radio link 200, the communication between the TD 10 and the emergency response team would be more reliable, and in addition, the power control instructions transmitted by the on-MDS BS transmitter within MDS 30A that are available in many wireless standards would result in lower average transmitted power at TD 10 due to the close-in distance to MDS 30A and better quality of radio link 200, and thereby increase the talk time of battery on TD 10 that may be necessary for the continuation of the location detection in progress. Said power control instructions transmitted by the on-MDS BS transmitter within MDS 30A can further take the advantage of being able to coordinate with the MDS 30A measurement activity to further increase the talk time of TD 10, and optimize the signal to interference ratio for better location measurement accuracy. Additional signal properties can also be controlled in coordination with the MDS 30A measurement activities for improved accuracy and battery life. In the same way as in the description of FIG. 4, after having determined the site where TD 10 is located, the MDS equipped vehicle 30A parks at a close location on site; the members of the emergency response team equipped with GRD 100A,100B walk off the vehicle 30A to approach the exact position of TD 10. Unlike in FIG. 4, the reference transmitter (to be further explained in the description of FIG. 9) within the GRD 100A,100B will set up a call via radio link 210A,210B with MDS 30A instead of BS 20A. The call properties on 100A,100B via radio link 210A,210B are otherwise the same as in FIG. 4, e.g., in the same operating mode as that of TD 10's call over radio link 200, preferred to be at the same frequency as that of TD 10 over 200, if possible, and when this is impossible (e.g., a call based on FDMA), a channel with as close frequency to the one on radio link 200 as possible is preferred. The way to utilize GRD 100A,100B to search for the exact position of TD 10 is also the same as in the description of FIG. 4. The down link of 210A,210B (from on-MDS BS transmitter within MDS 30A to the receiver associated with the reference transmitter within GRD 100A,100B) is preferred to perform a new task, to convey the data for display on the screens of GRD 100A,100B, in addition to the possible voice communication between the TD caller and the emergency response officer, eliminating the need for the WLAN transceivers on both MDS 30A,30B and GRD 100A,100B. Further, the power control instructions transmitted by the on-MDS BS transmitter within MDS 30A to the GRD 100A,100B can take the advantage of being able to coordinate with the MDS 30A measurement activity to optimize the signal to interference ratio for better location measurement accuracy of GRD 100A,100B, and increase the battery life of GRD 100A,100B as well. The frequency and other signal properties of the on-MDS BS transmitter should be chosen appropriately to minimize the impact to the wireless system operation of BS 20A,20B and their serving users.

Detail Description Paragraph:
[0051] FIG. 8 is a block diagram of the MDS in accordance with the preferred embodiments of the current invention. Referring to FIG. 8, the preferred embodiment of MDS 30 is composed of an antenna 305, a receiver 310, a GPS antenna 315, a GPS receiver 320, a digital signal processing (DSP) subsystem 325, a calibration

antenna 330, a calibration transmitter and mobile receiver 335, a display and user interface 345, a WLAN antenna 350, a WLAN transceiver 355, a gravity sensor 360 and a compass sensor 365. Optionally, the MDS 30 further includes an on-MDS BS transmitter 370 and a transmitting antenna 375.

Detail Description Paragraph:
[0053] The receiver 310 converts the RF (radio frequency) signals received by antenna 305 to baseband and digitizes the signals. The functionality of the receiver 310 is familiar to those skilled in the art, such as amplifying, down conversion, filtering, automatic gain control, analog to digital conversion, etc., and thereby does not need to elaborate further. For AOA measurement, preferably the receiver 310 is an array receiver that is composed by a plurality of identical channels whose down-conversion stages utilize a common or synchronized frequency source. Preferably said common frequency source is provided by the GPS receiver 320. The digitized baseband output of the receiver 310 is provided to the DSP subsystem 325 for further processing as will be further detailed thereafter.

Detail Description Paragraph:
[0055] The GPS antenna 315 receives signals from the GPS (Global Positioning System) satellites or from other satellites that perform the similar functionality, such as GLONASS (Global Navigation Satellite System), BEIDOU, or GALILEO in proposal, although still being referred to herein as GPS antenna. The antenna is preferably being installed on top roof of the moving platform to achieve good visibility of the satellites in sky. The signals received are provided to the GPS receiver 320.

Detail Description Paragraph:
[0056] The GPS receiver 320 receives signals from GPS satellites provided by the GPS antenna 315, or receive signals from other types of satellites providing the similar functionality such as GLONASS, BEIDOU or GALILEO, although still being referred to herein as GPS receiver. The GPS receiver 320 by receiving and processing the received signals from said satellites produces following output to the rest of the MDS 30: the accurate frequency and time reference source; the location of the MDS 30,30A,30B in terms of longitude, latitude and height as well as the moving direction of the MDS 30,30A,30B, or signals related to thereof.

Detail Description Paragraph:
[0059] The display and user interface unit 345 includes a screen to accept data from the DSP subsystems 325 to display the local map with overlaid symbols of TD 10 location, GRD 100,100A,100B location and the MDS 30,30A,30B location. Preferably the display also shows the stored remote sensing photo of local land structures, being overlaid on the local map. An example has been given in FIG. 5. The unit 345 also accepts user control to the MDS 30.

Detail Description Paragraph:
[0062] The compass sensor 365 reports the vehicle orientation to DSP subsystems 325 while vehicle is parked, for use to correct the AOA measurement computation in DSP subsystems 325. For the magnetic compass sensors, the sensor is preferably being calibrated by the direction computed by movement based on GPS while moving, to eliminate the magnetic interference of the vehicle structure.

Detail Description Paragraph:
[0064] The DSP subsystem 325 includes signal processing devices such as ASIC (application specific integrated circuits), FPGA (field programmable gate array), DSP processor(s), micro controller(s), and/or general purpose microprocessor(s), memory devices, mass storage devices and peripheral devices. The functionality of DSP subsystem 325 in MDS 30 includes: conducting calibration of the array receiver; computing the AOA, TOA, TDOA and/or other alternative or related parameters of the incoming signals from TD 10 and GRD 100,100A,100B; computing the longitude, latitude and height of the TD 10, GRD 100,100A,100B and MDS 30; while moving,

computing the direction of moving of the MDS 30 based on position changes of the MDS 30 reported by the GPS receiver 320; while staying stationary, finding the vehicle orientation based on input from the compass sensor 365; finding the vehicle tilt based on input from the gravity sensor 360; overlaying the positions of MDS 30 (provided by GPS receiver 320 or computed by DSP subsystem 325), the TD 10, and the GRD 100,100A,100B onto a local area map electronically stored in the mass storage device, rotating the overlaid image based on the vehicle moving direction or parking orientation, responding the user's command from user interface 345 to zoom, move, or attribute change to the image, and producing the final image for display; outputting said image to the display and user interface unit 345; outputting the image or image parameters to the WLAN transceiver 355 to transmit to the GRD 100,100A,100B for display on the GRD screen(s); controlling and configuring all functional parts within MDS 30. When the on-MDS BS transmitter 370 and its associated antenna 375 (to be described in the next paragraph) is equipped within MDS 30, the DSP subsystem 325 (together with receiver 310) further performs all additional functionalities that a BS receiver will perform, e.g., decoding of the in coming signals from TD 10 that are passed to DSP subsystem 325 by receiver 310.

Detail Description Paragraph:
[0066] FIG. 9 is a block diagram of the GRD in accordance with the preferred embodiments of the current invention. Now referring to FIG. 9, the preferred embodiment of GRD 100 is composed of a reference transmitter 440, an antenna 450 for the reference transmitter, a WLAN transceiver 430, an antenna 460 for the WLAN transceiver, a microprocessor 410, and a display and user interface unit 420. In alternative embodiments as will be further detailed later, the GRD 100 further includes a GPS receiver 480 and an antenna 490 for the GPS receiver, and a compass sensor 470.

Detail Description Paragraph:
[0069] The microprocessor 410 controls and configures all the functional units in the GRD 100. It also accepts user commands from display and user interface unit 420 to control the GRD 100, including to control the display on the screen, such as zoom, move, change attributes and formats of the image.

Detail Description Paragraph:
[0071] In yet another alternative embodiment, while GRD 100 is used in an area where GPS signals are of sufficiently good quality, the GPS receiver 480 and the GPS antenna 490 that are also included in the GRD 100 receive signals from GPS satellites and reports the location of GRD 100 to the microprocessor 410. The reported position will be transmitted back to MDS 30 via the WLAN transceiver 430 and antenna 460. Upon receipt of the location from GPS receiver 480 in GRD 100, the MDS 30 will use said location information to correct the GRD locations measured by MDS 30 itself.

CLAIMS:

21. The method of claim 15 wherein said display of the relative positions of said target wireless transmitting device, said reference transmitting device(s) and said movable detection station(s) is shown on at least one displaying device(s) of: a guiding device used by searching personnel(s); a movable detection station; a searching robot control station; a public safety answering point; a dispatch center; and a command center.

26. The method of claim 15 wherein said display of the positions of said target wireless transmitting device, said reference transmitting device(s) and said movable detection station(s) is overlaid on top of a pre-stored electronic map image of local area, and optionally further overlaid on top of a remote sensing photo of local land structures.

29. The method of claim 15 wherein said determination of positions and said guiding

of search can be improved by further including the steps of: determining the absolute positions of said movable detection station(s) and said movable reference wireless transmitting device(s) in at least two dimensions, using either a GPS based method (or alike) or an inertia based method or both; and correcting said estimated relative positions using said determined absolute positions.

37. A movable detection station for determining the location of a wireless transmitting device(s), and guiding the search for said wireless transmitting device(s), comprising: a first antenna; a first receiver, input from said first antenna, for receiving signals from said wireless transmitting device(s), and producing digitized baseband signals; a second antenna; a second receiver, input from said second antenna, for receiving signals from GPS satellites (or other similar systems), producing precise frequency reference and timing to said first receiver, and producing digitized GPS (or similar) information related to the location and orientation of the movable detection station in question; a display and user interface unit, for presenting the location and guiding information to the user and accepting user control to the movable detection station in question; and a digital signal processing unit, coupled to said first and second receivers, and to said display and user interface unit, performing. signal parameter measurements on the signals provided by the first receiver, determining the location and orientation of said movable detection station in question, determining and refining the location estimation of said wireless transmitting device(s), accepting user controls through said display and user interface unit, producing information for display on said display and user interface unit, and controlling all the elements within the movable detection station.

47. The guiding and reference device of claim 45 further comprising: a GPS antenna; a GPS receiver, coupled to said GPS antenna and said microprocessor, receiving GPS signals (or signals from similar systems) for obtaining absolute position information, and passing said information to said microprocessor and then further transmitting to a detection station through said transceiver and said second antenna; a compass sensor, coupled to said microprocessor, providing orientation information of said guiding and reference device for image rotation and displaying processing.

L16: Entry 1 of 1 File: PGPB Dec 4, 2003

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TITLE: Complete vehicle control

Pre-Grant Publication (PGPub) Document Number:
20030225495

Summary of Invention Paragraph:
[0005] One aspect of the present invention is to provide a method of controlling a vehicle. The method includes the step of inputting an intended driving demand to a vehicle motion control subsystem, with the intended driving demand requesting a vehicle behavior modification. The method also includes the steps of proving a plurality coordinator subsystems, providing at least one actuator control subsystem for each coordinator subsystem, outputting actuator capabilities of the at least one actuator control subsystem to an associated one of the plurality of coordinator subsystems, and outputting coordinator capabilities of each coordinator subsystem to the vehicle motion control subsystem. The method further includes the step of calculating at least one coordinator demand signal with the vehicle motion control subsystem, with the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand. The method also includes the step of outputting the at least one coordinator demand signal to at least one of the coordinator subsystems. The method further includes the step of calculating the at least one coordinator demand signal with each of the at least one of the coordinator subsystems, with the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal. The method also includes the step of outputting the at least one actuator demand signal to the at least one actuator control subsystem. A combination of each at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

Summary of Invention Paragraph:
[0006] Another aspect of the present invention is to provide a vehicle control system comprising a vehicle motion control subsystem, a plurality of coordinator subsystems and at least one actuator control subsystem. The vehicle motion control subsystem has a control input and a control output, with the control input communicating an intended driving demand to the vehicle motion control subsystem. The intended driving demand requests a vehicle behavior modification. Each coordinator subsystem includes a coordinator input and a coordinator output, with each coordinator subsystem communicating coordinator capabilities of the coordinator subsystem to the system input of the vehicle motion control subsystem. At least one actuator control subsystem is provided for each coordinator subsystem. Each actuator control subsystem has an actuator output communicating actuator capabilities of the actuator control subsystem to the coordinator input of an associated one of the plurality of coordinator subsystems. The vehicle motion control subsystem calculates at least one coordinator demand signal, with the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand. The vehicle motion control subsystem also outputs the at least one coordinator demand signal to the coordinator input of

at least one of the coordinator subsystems. Furthermore, each coordinator subsystem calculates at least one actuator demand signal, with the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal. Additionally, each coordinator subsystem outputs the at least one actuator demand signal to at least one actuator control subsystem. A combination of each at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

Detail Description Paragraph:
[0022] In the illustrated example, the coordinator subsystems 16 communicate with the vehicle motion control subsystem 12 for receiving inputs for carrying out the intended driving demand 14. The coordinator subsystems 16 preferably include the steering coordinator subsystem 18, the drive train and brakes coordinator subsystem 20, and the suspension coordinator subsystem 22. Each of the coordinator subsystems 16 include an input that receives a signal from the vehicle motion control subsystem 12 commanding the coordinator subsystem 16 to implement a particular vehicle behavior modification. Therefore, the steering coordinator subsystem 18 receives a steering behavior modification demand signal conveying a steering behavior modification demand from the vehicle motion control subsystem 12. The steering behavior modification demand instructs the steering coordinator subsystem 18 to make a steering behavior modification (e.g., steer the vehicle in a certain lateral direction). Likewise, the drive train and brakes coordinator subsystem 20 receives a drive train and brakes behavior modification demand signal conveying a drive train and brakes behavior modification demand from the vehicle motion control subsystem 12. The drive train and brakes behavior modification demand instructs the drive train and brakes coordinator subsystem 20 to make a drive train and brakes behavior modification (e.g., move the vehicle in a certain longitudinal direction). Moreover, the suspension coordinator subsystem 22 receives a suspension behavior modification demand signal conveying a suspension behavior modification demand from the vehicle motion control subsystem 12. The suspension behavior modification demand instructs the suspension coordinator subsystem 22 to make a suspension behavior modification (e.g., manipulate the vehicle in a certain vertical (heave) direction). Each behavior modification demand of the coordinator subsystems 16 can also affect the motion of the vehicle in other directions. For example, the steering coordinator subsystem 18 can affect the yaw motion of the vehicle by turning the front wheels of the vehicle and can affect the roll motion of the vehicle by turning (thereby causing the side of the vehicle with the smaller turning radius to roll upward). As additional examples, the drive train and brakes coordinator subsystem 20 can affect the yaw motion by braking only one side of the vehicle and the suspension coordinator subsystem 22 can affect the longitudinal motion of the vehicle by altering the suspension of the vehicle to provide for improved traction. Furthermore, as discussed in more detail below, each coordinator subsystem 16 also provides an output to the vehicle motion control subsystem 12 for communicating capabilities of the coordinator subsystems 16. The capabilities of the coordinator subsystems 16 are the combination of the actuator control subsystems 26 communicating with an associated coordinator subsystem 16. Although three coordinator subsystems 16 are shown and described herein, it is contemplated that any number of coordinator subsystems 16 can be used in the vehicle control system.

Detail Description Paragraph:
[0036] The illustrated vehicle control system of the present invention enhances the performance of the vehicle by distributing commands from the vehicle motion control subsystem 12 to the coordinator subsystems 16 based upon physical capabilities of the actuator control subsystems 26. Referring to FIGS. 5A and 5B, a method 50 of controlling a vehicle with the vehicle control system is shown. Beginning at step 52 of the method 50 of controlling the vehicle, the driver inputs from the driver 11 of the vehicle are inputted into the driver subsystem 15. The driver inputs are processed as discussed above and then sent to the active assist subsystem 17 at

step 54.

Detail Description Paragraph:
[0038] The next three steps in the method of controlling a vehicle occur continuously, even if the intended driving demand 14 is not being input into the vehicle motion control subsystem 12. First, the vehicle state measurements are inputted into the vehicle motion control subsystem 12 from the vehicle state estimator 28 and data therefrom is transferred to each control tier in the vehicle control system at step 62. Second, the coordinator subsystems 16 will determine their capabilities at step 64. As discussed in more detail below, the capabilities of each coordinator subsystem 16 are a combination of all of the capabilities of the actuator control subsystems 26 functionally located under each coordinator subsystem 16 as determined by the data of the vehicle state measurements and measurements from actuator state estimators communicating with each actuator control subsystem 26. For example, a first one of the coordinator subsystems 16 can be the drive train and brakes coordinator subsystem 20 determining that it is capable of providing up to 3.0 Newton meters of braking wheel torque as measured by a combination of the braking wheel torque capabilities of the actuator control subsystems 26 communicating with the drive train and brakes coordinator subsystem 20. Although the drive train and brakes coordinator subsystem 20 is used in the above example, the coordinator subsystems 16 in step 64 could be any of the coordinator subsystems 16. Third, the coordinator subsystems 16 will output their capabilities to the vehicle motion control subsystem 12 at step 66.

Detail Description Paragraph:
[0041] The illustrated suspension coordinator subsystem 22 of the present invention also enhances the performance of the suspension of the vehicle by distributing commands from the suspension coordinator subsystem 22 to the actuator control subsystems 26 functionally located below the suspension coordinator subsystem 22 based upon physical capabilities of the actuator control subsystems 26. Referring to FIG. 6, a method 200 of controlling a suspension of a vehicle with the suspension coordinator subsystem 22 subsystem is shown. Beginning at step 202 of the method 200 of controlling the suspension of the vehicle, the suspension behavior modification demand signal is inputted into the suspension coordinator subsystem 22. The suspension behavior modification demand signal is a signal sent to the suspension coordinator subsystem 22 directing the suspension coordinator subsystem 22 to perform a particular behavior modification of the suspension of the vehicle (i.e., the suspension behavior modification).

Detail Description Paragraph:
[0042] The actuator control subsystems 26 receive the vehicle state measurements from the vehicle state estimator 28 (via the motion control subsystem 12 and the suspension coordinator subsystem 22) that provide the state of the vehicle and actuator state measurements from an actuator state estimator that provide the state of the actuators at step 204. As seen in FIG. 1, the vehicle state measurements are preferably transferred to the actuator control subsystems 26 through the vehicle motion control subsystem 12 and the suspension coordinator subsystem 22, although it is contemplated that the vehicle state measurements could be directly inputted into the actuator control subsystems 26. The actuator state measurements are preferably inputted directly into the actuator control subsystems 26. After the vehicle state measurements and actuator state measurements are inputted into the actuator control subsystems 26, the actuator control subsystems 26 will determine their capabilities to perform functions with the vehicle in the state of the vehicle state measurements and actuator state measurements at step 206. The vehicle state measurements are used to determine the capabilities of the actuator control subsystems 26 because the vehicle state measurements will communicate the speed of the vehicle, the movement of the vehicle in six directions, etc. to the actuator control subsystems 26, all of which are used along with the actuator state measurements (which provide the current state of the actuators of and controlled by the actuator control subsystems 26) to determine the capabilities of the actuator

control subsystems 26. For example, a first actuator control subsystem 26 can be the leveling control subsystem 46 determining that it is capable of providing up to 3.0 Newtons of vertical force as determined by the load of the vehicle (a vehicle state measurement) and possible air input into an air-suspension level-control system (an actuator state measurement). Although the leveling actuator control subsystem 46 is used in the above example, the actuator control subsystem 26 could be any of the actuator control subsystems 26 under the suspension coordinator subsystem 22. Furthermore, although the step 202 of inputting the suspension behavior modification demand into the suspension coordinator subsystem 22 is shown as occurring before the step 204 of receiving the vehicle state measurements and the actuator state measurements by the first actuator control subsystem 26 and the step 206 of determining the actuator capabilities of the actuator control subsystems 26, steps 204 and 206 can occur simultaneously to or before the step 202 of inputting the suspension behavior modification demand into the suspension coordinator subsystem 22. Preferably, both steps 204 and 206 will occur continuously in the vehicle control system.

Detail Description Paragraph:
[0043] After the actuator control subsystems 26 have determined their capabilities, each actuator control subsystem 26 will output a capability signal to the suspension coordinator subsystem 22 communicating the capabilities of each actuator control subsystem 26 at step 208. At this point, the suspension coordinator subsystem 22 will then calculate at least one partial suspension behavior modification demand signal at step 210 (along with combining the capabilities of the actuator control system 26 to form the coordinator capability of the suspension coordinator subsystem 22 for reporting to the vehicle motion control subsystem 12 as discussed above). A first partial suspension behavior modification demand signal will tell a first actuator control subsystem 26 to perform within its first capabilities. Likewise, a second partial suspension behavior modification demand signal will tell a second actuator control subsystem 26 to perform within its second capabilities. Moreover, a third partial suspension behavior modification demand signal will tell a third actuator control subsystem 26 to perform within its third capabilities. Consequently, the first partial suspension behavior modification demand signal, the second partial suspension behavior modification demand signal and/or the third partial suspension behavior modification demand signal will provide directions for a first actuator control subsystem 26, the second actuator control subsystem 26 and/or the third actuator control subsystem 26, respectively, to perform the suspension behavior modification of the suspension behavior modification demand signal. Furthermore, the first partial suspension behavior modification demand signal, the second partial suspension behavior modification demand signal and the third partial suspension behavior modification demand signal are therefore calculated according to the first capabilities of the first actuator control subsystem 26, the second capabilities of the second actuator control subsystem 26 and/or the third capabilities of the third actuator control subsystem 26. For example, if the suspension behavior modification demand signal requires more from a single actuator control subsystem than it is capable of providing (as determined by its capabilities), more than one partial suspension behavior modification demand signal will be calculated, with a first partial suspension behavior modification demand signal being determined according to the capabilities of a first actuator control system (i.e., requesting the first actuator control system to perform within its capabilities) and a second partial suspension behavior modification demand signal that depends on the capabilities of the first actuator control subsystem (a suspension behavior modification demand of the suspension behavior modification demand signal remaining after the first partial suspension behavior modification demand signal is removed).

Detail Description Paragraph:
[0045] The illustrated drive train and brakes coordinator subsystem 22 of the present invention also enhances the performance of the drive train and brakes of the vehicle by distributing commands from the drive train and brakes coordinator

subsystem 22 to the actuator control subsystems 26 based upon physical capabilities of the actuator control subsystems 26 functionally located below the drive train and brakes coordinator subsystem 22. Referring to FIG. 7, a method 300 of controlling a drive train and brakes of a vehicle with the drive train and brakes coordination 22 subsystem is shown. Beginning at step 302 of the method 300 of controlling the drive train and brakes of the vehicle, the drive train and brakes behavior modification demand signal is inputted into the drive train and brakes coordinator subsystem 22. The drive train and brakes behavior modification demand signal is a signal sent to the drive train and brakes coordinator subsystem 22 directing the drive train and brakes coordinator subsystem 22 to perform a particular behavior modification of the drive train and brakes of the vehicle (i.e., the drive train and brakes behavior modification).

Detail Description Paragraph:
[0046] The actuator control subsystems 26 receive the vehicle state measurements from the vehicle state estimator 28 (via the motion control subsystem 12 and the drive train and brakes coordinator subsystem 22) that provide the state of the vehicle and actuator state measurements from an actuator state estimator that provide the state of the actuators at step 304. As seen in FIG. 1, the vehicle state measurements are preferably transferred to the actuator control subsystems 26 through the vehicle motion control subsystem 12 and the drive train and brakes coordinator subsystem 22, although it is contemplated that the vehicle state measurements could be directly inputted into the actuator control subsystems 26. The actuator state measurements are preferably inputted directly into the actuator control subsystems 26. After the vehicle state measurements and actuator state measurements are inputted into the actuator control subsystems 26, the actuator control subsystems 26 will determine their capabilities to perform functions with the vehicle in the state of the vehicle state measurements and actuator state measurements at step 306. The vehicle state measurements are used to determine the capabilities of the actuator control subsystems 26 because the vehicle state measurements will communicate the speed of the vehicle, the movement of the vehicle in six directions, etc. to the actuator control subsystems 26, all of which are used along with the actuator state measurements (which provide the current state of the actuators of and controlled by the actuator control subsystems 26) to determine the capabilities of the actuator control subsystems 26. For example, a first actuator control subsystem 26 can be the engine control subsystem 36 determining that it is capable of providing up to 3.0 Newton meters of wheel torque as determined by the speed of the vehicle (a vehicle state measurement) and possible fuel input into an engine (an actuator state measurement). Although the engine control subsystem 36 is used in the above example, the actuator control subsystem 26 could be any of the actuator control subsystems 26 under the drive train and brakes coordinator subsystem 22. Furthermore, although the step 302 of inputting the drive train and brakes behavior modification demand into the drive train and brakes coordinator subsystem 22 is shown as occurring before the step 304 of receiving the vehicle state measurements and the actuator state measurements by the first actuator control subsystem 26 and the step 306 of determining the actuator capabilities of the actuator control subsystems 26, steps 304 and 306 can occur simultaneously to or before the step of inputting the drive train and brakes behavior modification demand into the drive train and brakes coordinator subsystem 22. Preferably, both steps 304 and 306 will occur continuously in the vehicle control system.

Detail Description Paragraph:
[0047] After the actuator control subsystems 26 have determined their capabilities, each actuator control subsystem 26 will output a capability signal to the drive train and brakes coordinator subsystem 22 communicating the capabilities of each actuator control subsystem 26 at step 308. At this point, the drive train and brakes coordinator subsystem 22 will then calculate at least one partial drive train and brakes behavior modification demand signal at step 310 (along with combining the capabilities of the actuator control system 26 to form the

coordinator capability of the drive train and brakes coordinator subsystem 22 for reporting to the vehicle motion control subsystem 12 as discussed above). A first partial drive train and brakes behavior modification demand signal will tell a first actuator control subsystem 26 to perform within its first capabilities. Likewise, a second partial drive train and brakes behavior modification demand signal will tell a second actuator control subsystem 26 to perform within its second capabilities. Moreover, a third partial drive train and brakes behavior modification demand signal will tell a third actuator control subsystem 26 to perform within its third capabilities. Consequently, the first partial drive train and brakes behavior modification demand signal, the second partial drive train and brakes behavior modification demand signal and/or the third partial drive train and brakes behavior modification demand signal will provide directions for a first actuator control subsystem 26, the second actuator control subsystem 26 and/or the third actuator control subsystem 26, respectively, to perform the drive train and brakes behavior modification of the drive train and brakes behavior modification demand signal. Furthermore, the first partial drive train and brakes behavior modification demand signal, the second partial drive train and brakes behavior modification demand signal and the third partial drive train and brakes behavior modification demand signal are therefore calculated according to the first capabilities of the first actuator control subsystem 26, the second capabilities of the second actuator control subsystem 26 and the third capabilities of the third actuator control subsystem 26. For example, if the drive train and brakes behavior modification demand signal requires more from a single actuator control subsystem than it is capable of providing (as determined by its capabilities), more than one partial drive train and brakes behavior modification demand signal will be calculated, with a first partial drive train and brakes behavior modification demand signal being determined according to the capabilities of a first actuator control system (i.e., requesting the first actuator control system to perform within its capabilities) and a second partial drive train and brakes behavior modification demand signal that depends on the capabilities of the first actuator control subsystem (a drive train and brakes behavior modification demand of the drive train and brakes behavior modification demand signal remaining after the first partial drive train and brakes behavior modification demand is removed).

CLAIMS:

1. A method of controlling a vehicle comprising: inputting an intended driving demand to a vehicle motion control subsystem, the intended driving demand requesting a vehicle behavior modification; proving a plurality of coordinator subsystems; providing at least one actuator control subsystem for each coordinator subsystem; outputting actuator capabilities of the at least one actuator control subsystem to an associated one of the plurality of coordinator subsystems; outputting coordinator capabilities of each coordinator subsystem to the vehicle motion control subsystem; calculating at least one coordinator demand signal with the vehicle motion control subsystem, the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand; outputting the at least one coordinator demand signal to at least one of the coordinator subsystems; calculating at least one actuator demand signal with each of the at least one of the coordinator subsystems, the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal outputted to the at least one of the coordinator subsystems; and outputting the at least one actuator demand signal to the at least one actuator control subsystem; wherein a combination of each at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

6. The method of controlling a vehicle of claim 1, further including: inputting actuator state measurements into the at least one actuator control subsystem; wherein the actuator capabilities of the at least one actuator control subsystem

are determined according to the actuator state measurements.

7. The method of controlling a vehicle of claim 6, wherein: the coordinator capabilities for the associated one of the plurality of coordinator subsystems are determined according to the actuator capabilities of the at least one actuator control subsystem outputting the actuator capabilities to the associated one of the plurality of coordinator subsystems.

8. A vehicle control system comprising: a vehicle motion control subsystem having a control input and a control output, the control input communicating an intended driving demand to the vehicle motion control subsystem, the intended driving demand requesting a vehicle behavior modification; a plurality of coordinator subsystems, each coordinator subsystem including a coordinator input and a coordinator output, each coordinator subsystem communicating coordinator capabilities of the coordinator subsystem to the system input of the vehicle motion control subsystem; and at least one actuator control subsystem for each coordinator subsystem, each actuator control subsystem having an actuator output communicating actuator capabilities of the actuator control subsystem to the coordinator input of an associated one of the plurality of coordinator subsystems; wherein the vehicle motion control subsystem calculates at least one coordinator demand signal, the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand; wherein the vehicle motion control subsystem outputs the at least one coordinator demand signal to the coordinator input of at least one of the coordinator subsystems; wherein each coordinator subsystem calculates at least one actuator demand signal, the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal outputted to the at least one of the coordinator subsystems; wherein each coordinator subsystem outputs the at least one actuator demand signal to at least one actuator control subsystem; and wherein a combination of each at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

13. The vehicle control system of claim 8, wherein: actuator state measurements are input into the at least one actuator control subsystem; and the actuator capabilities of the at least one actuator control subsystem are determined according to the actuator state measurements.

14. The vehicle control system of claim 13, wherein: the coordinator capabilities for the associated one of the plurality of coordinator subsystems are determined according to the actuator capabilities of the at least one actuator control subsystem outputting the actuator capabilities to the associated one of the plurality of coordinator subsystems.

16. The method of controller a vehicle of claim 15, wherein: the implementation subsystem includes a plurality coordinator subsystems and at least one actuator control subsystem for each coordinator subsystem; and further including the steps of: outputting actuator capabilities of the at least one actuator control subsystem to an associated one of the plurality of coordinator subsystems; outputting coordinator capabilities of each coordinator subsystem to the vehicle motion control subsystem; calculating at least one coordinator demand signal with the vehicle motion control subsystem, the at least one coordinator demand signal being determined according to the coordinator capabilities and the intended driving demand; the step of outputting at least a portion of the intended driving demand includes outputting the at least one coordinator demand signal to at least one of the coordinator subsystems; calculating at least one actuator demand signal with each of the at least one of the the coordinator subsystems, the at least one actuator demand signal being determined according to the actuator capabilities and the at least one coordinator demand signal outputted to the at least one of the coordinator subsystem; and outputting the at least one actuator demand signal to

the at least one actuator control subsystem; wherein the at least one actuator demand signal provides directions for the at least one actuator control subsystem to perform the vehicle behavior modification of the intended driving demand.

17. The method of controlling a vehicle of claim 16, further including: inputting actuator state measurements into the at least one actuator control subsystem; wherein the actuator capabilities of the at least one actuator control subsystem are determined according to the actuator state measurements.

18. The method of controlling a vehicle of claim 17, wherein: the coordinator capabilities for the associated one of the plurality of coordinator subsystems are determined according to the actuator capabilities of the at least one actuator control subsystem outputting the actuator capabilities to the associated one of the plurality of coordinator subsystems.

Previous Doc   Next Doc   Go to Doc#